1090-WP-17-04
27 January 2003

<u>RTCA Special Committee 186, Working Group 3</u>

<u>ADS-B 1090 MOPS, Revision A</u>

<u>Meeting #17</u>

Effects of Altitude

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SUMMARY

I'm submitting this paper to WG-3 as additional material to support a comment I made on the MOPS. The comment is that the altitude material in section P.3.3 is oversimplified, and not quite correct. Although it's not a critical matter, I think it would be helpful for some future readers if we made this correction.

Effects of Altitude

Section P.3.3 addresses the issue of the altitude of the transmitting aircraft, while the altitude of the receiving aircraft is 40,000 feet in all cases considered. The conclusion stated in P.3.3 is that beyond 50 NM air-to-air, the effects of altitude of the transmitting aircraft are insignificant, and therefore the evaluation results can be used for any transmitter altitude. After the completed MOPS was distributed, this issue was re-opened because of concern for differences between the Lincoln and APL results at ranges shorter than 50 NM. While surveillance performance satisfies the MASPS standards well beyond 50 NM, the TSR performance is less, so the altitude analysis should be considered for those shorter ranges as well.

Additional results have now been generated, as summarized below, to compare performance as a function of the altitude of the transmitting aircraft. The additional results indicate that altitude effects are large enough to cause a significant change in the final system range as defined by the intersection point of performance with the MASPS requirements.

There is one more reason for making a slight change to the altitude figure, Figure P-25. The data in the figure were computed using the previous version of the simulation in which the top and bottom receiving antennas were characterized by statistical independence. At the November meeting, this was changed to use just the better of the two antennas, which is the way the simulation is documented in P.3.2.1 and the final results were generated. As a result, the data points in Figure P-25 are not quite consistent with the data points in Figure P-21. For consistency, we should replace Figure P-25 with a consistent version (given in my draft).

ANALYSIS OF TRANSMITTER ALTITUDE

We have used the track-level simulation to assess the effects of altitude, focusing attention on the case of A3-A2 TSR performance in the LA2020-nominal environment. This is an interesting case, which caught our attention because Lincoln's result is Rmax = 40 NM, which satisfies the MASPS standard for TSR, but APL's result is only 20 NM. This case is also particularly interesting because both Lincoln and APL used exactly the same receiver performance data points, which are plotted in Figure P-19 (the open circles). These data points were generated by Lincoln's pulse-level simulation, and used as input to Lincoln's track-level simulation and also APL's simulation.

The Lincoln evaluation is formulated to apply to cases in which the transmitting aircraft is at the same altitude as the receiving aircraft, here 40,000 feet. To study altitude effects, we modified the LL simulation making the altitude of the transmitting aircraft a parameter than can be assigned any value.

SIMULATION RESULTS

We ran the simulation for several values of transmitter altitude, yielding the results plotted in Figure 1.

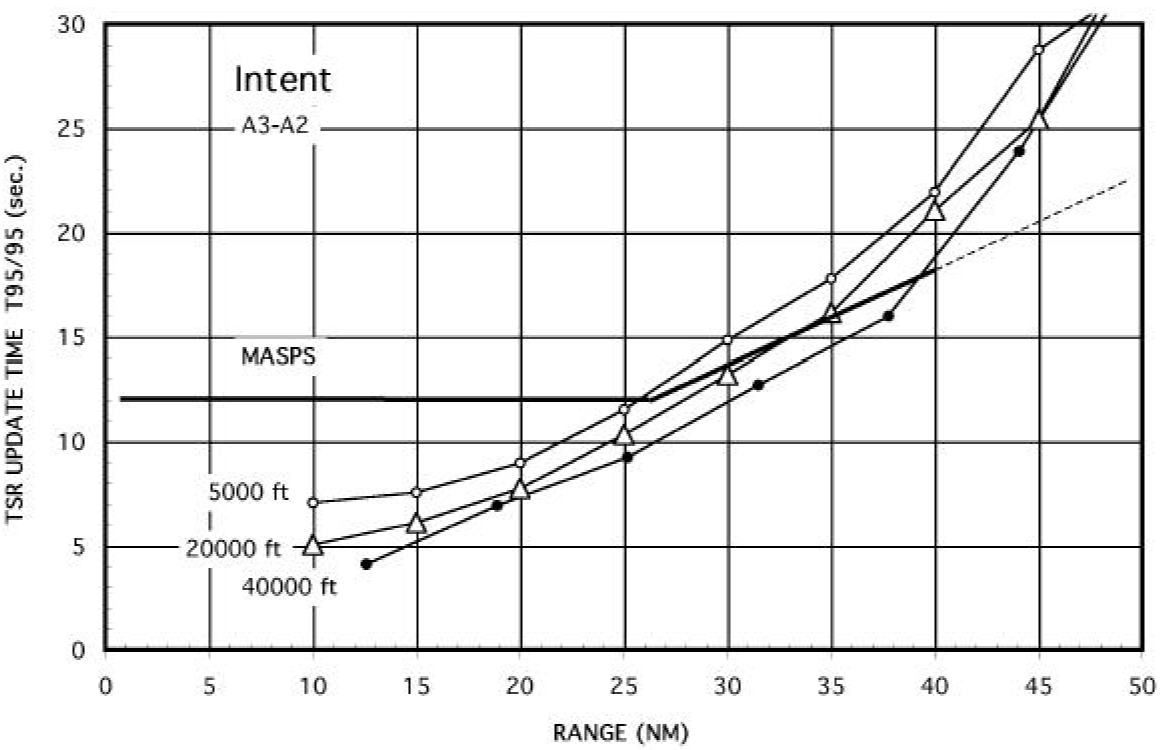

Figure 1. Altitude Effects on TSR Performance
(A3-A2, LA2020-Nominal)
Altitudes marked in the figure apply to the transmitting aircraft.
The receiving aircraft is at 40,000 feet.

The performance results in this figure indicate that the altitude of the transmitting aircraft has a small but significant effect for ranges less than 50 NM. It's interesting to see that the slope of the performance curves is close to the slope of the MASPS requirement, and as a result a small shift in the performance curve can cause quite a large change in the range at which the performance intersects the MASPS requirement.

We believe that the results of primary interest are for cases in which both aircraft are in the same altitude regime. The results in the figure above indicate that performance is not very sensitive to transmitter altitude between 20,000 and 40,000 feet. The sensitivity increases for very low altitude transmitters.

Looking at this figure, one other point comes to mind. As the performance curve is degraded, either by reducing the altitude of the transmitter or by increasing fruit, the similarity of slopes causes the intersection point to drop more rapidly. If the intersection point is low, as in the 5000 foot curve above, the performance beyond the point of intersection is not much worse than the MASPS requirement. For example, for altitude = 5000 feet and R = 40 nmi, this range is far beyond maximum range intersecting the MASPS requirement, but at 40 nmi the requirement is 18 seconds, and the performance is 23 seconds, which is not much different. Bearing in mind that the MASPS requirement was adopted before developing applications, it seems likely that applications can be developed for the actual performance well beyond the point of intersection at 25 nmi.

To make the corrections to Appendix P, I've drafted revised wording, which was supplied along with my MOPS comments.